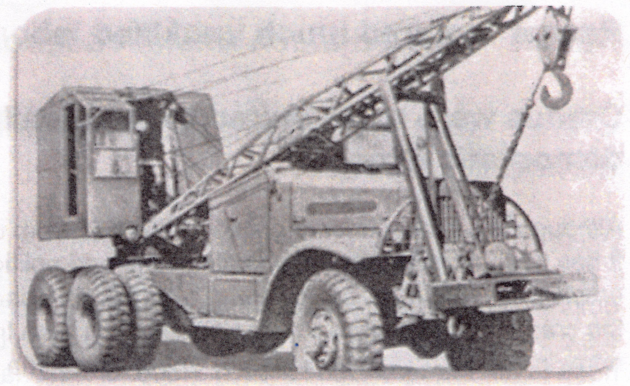


Module 1

History of Cranes



Learning Objectives

By the end of this section, you will:

1. Understand the importance of leverage principles in the history of cranes.
2. Know the law of leverage.
3. Know tipping point.

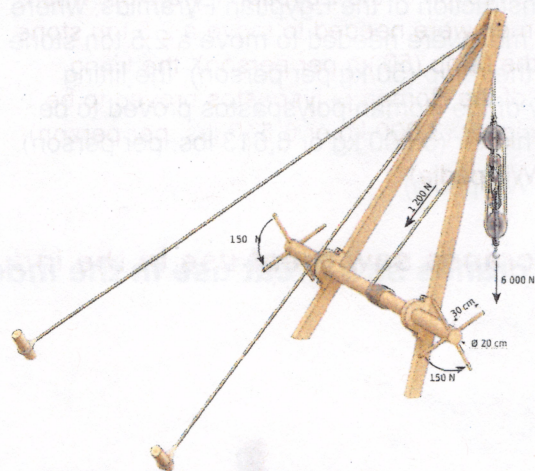
The crane was invented by the Greeks in 6th Century B.C.

The crane for lifting heavy loads was invented by the Ancient Greeks in the late 6th century BC. The archaeological record shows that no later than 515 BC distinctive cuttings for both lifting tongs begin to appear on stone blocks of Greek temples. Since these holes point at the use of a lifting device, and since they are to be found either above the center of gravity of the block, or in pairs equidistant from a point over the center of gravity, they are regarded by archaeologists as the positive evidence required for the existence of the crane.

The introduction of the winch and pulley hoist soon lead to a widespread replacement of ramps as the main means of vertical motion.

For the next two hundred years, Greek building sites witnessed a sharp drop in the weights handled, as the new lifting technique made the use of several smaller stones more practical than of fewer larger ones.

The first unequivocal literary evidence for the existence of the compound pulley system appears in the Mechanical Problems attributed to Aristotle (384–322 BC), but perhaps composed at a slightly later date. Around the same time, block sizes at Greek temples began to match their archaic predecessors again, indicating that the more sophisticated compound pulley must have found its way to Greek construction sites by then.



3-Pulley Crane Capable of lifting 330 pounds

Ramps required much unskilled labor.

Cranes were more suited to the small professional construction teams of democratic Greece.

Although the exact circumstances of the shift from the ramp to the crane technology remain unclear. It has been argued that the volatile social and political conditions of Greece were more suitable to the employment of small, professional construction teams than of large bodies of unskilled labor, making the crane more preferable to the Greek polis than the more labor-intensive ramp which had been the norm in the autocratic societies of Egypt or Assyria.

Romans widely used cranes operated by treadwheels.

This crane called a polypastos, when worked by four men at both sides of the winch, could readily lift 3,000 kg (6,613 lbs.) (3 ropes x 5 pulleys x 4 men x 50 kg = 3,000 kg). If the winch was replaced by a treadwheel, the maximum load could be doubled to 6,000 kg at only half the crew, since the treadwheel possesses a much bigger mechanical advantage due to its larger diameter. This meant that, in comparison to the construction of the Egyptian Pyramids, where about 50 men were needed to move a 2.5 ton stone block up the ramp (50 kg per person), the lifting capability of the Roman polypastos proved to be 60 times higher (3,000 kg or 6,613 lbs. per person).

(Source: Wikipedia)



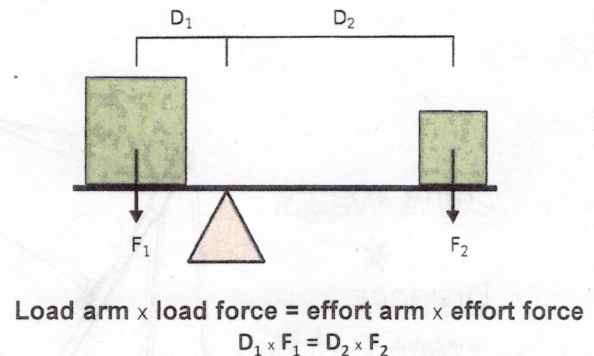
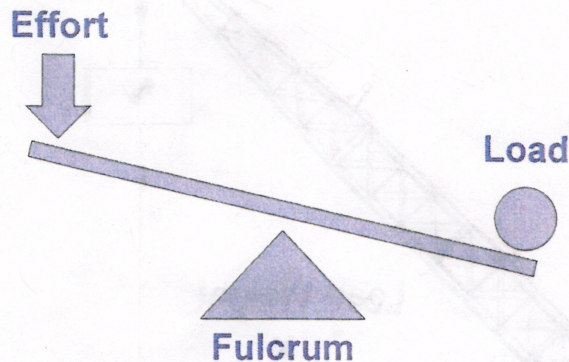
Steam cranes saw great use in the industrial revolution.



Leverage

The lever is one of the basic tools that dates back to prehistoric times.

A beam, or lever, is used to move a load with a fulcrum, or pivot, and an applied force. The position of the three determines the mechanical advantage.



The Law of Leverage

The point where you apply the force is called the effort. The effect of applying this force is called the load. The load arm (D_1) and the effort arm (D_2) are the names given to the distances from the fulcrum to the load and effort, respectively.

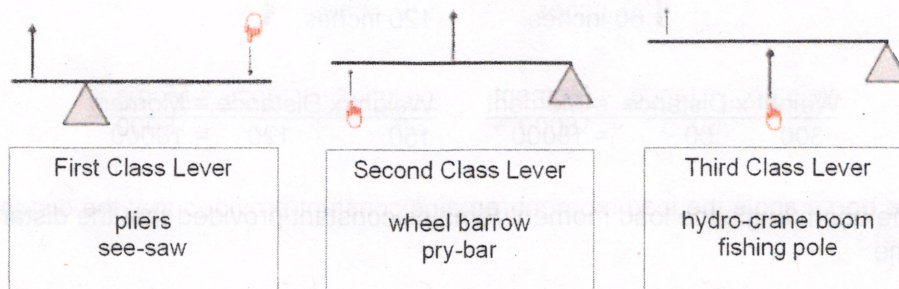
Using these definitions, the Law of the Lever is:

$$\text{Load arm} \times \text{load force} = \text{effort arm} \times \text{effort force}$$

For example, if a 1 gram feather were balanced by a one kilogram rock, the feather would be 1000 times further from the fulcrum than the rock; if a 1 kilogram rock were balanced by another 1 kilogram rock, the fulcrum would be in the middle.

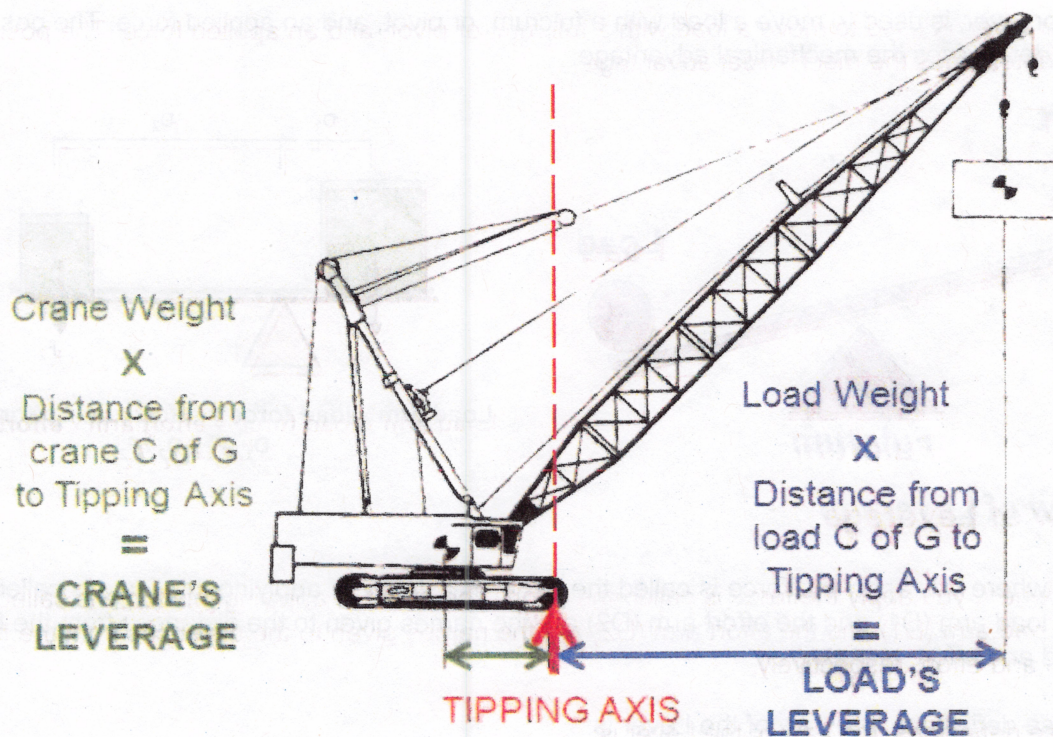
To use a lever to lift a certain unit of weight with a force of half a unit, the distance from the fulcrum to the spot where force is applied must be exactly twice that of the distance between the weight and the fulcrum. For example, to cut in half the force required to lift a weight resting 1 foot from the fulcrum, we would need to apply force 2 feet from the other side of the fulcrum.

There are classes of levers.



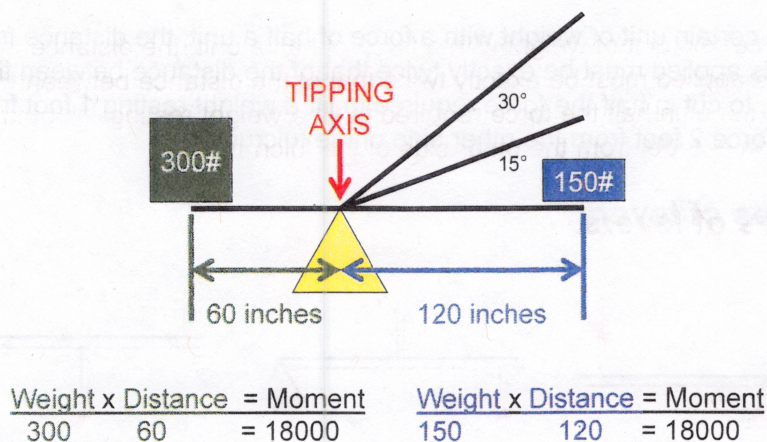
Crane stability is based on the principle of leverage.

Crane leverage must be greater than the load leverage. If the load leverage is greater than crane leverage the crane will tip and the crane components will fail.



**“Load moment” is a product of:
The magnitude of the load X the “moment arm”.**

These values are critical to determining the capacity of the crane!



Regardless of the boom angle the load moment remains constant provided that the distance and weight remains the same.